ISSN 2289-6376 DIGES PMU 8 (2021) 219–223

An Integration of Smart Garden with IoT Technology

Muhammad Thariq Abdul Razak[1,*], Aaron Lennon[1], and Ernymayan Nyalu[1]
[1]Jabatan Teknologi Maklumat dan Telekomunikasi, Politeknik Mukah, KM 7.5, Jalan Oya
96400 Mukah, Sarawak, Malaysia
*Corresponding author: m.thariq@pmu.edu.my

Abstract

Internet of Things (IoT) is a domain of technology that brings remarkable advancement in every field of life, whether it's industry or agriculture. Our lives are essentially dependent on agricultural development. IoT is a domain of computer science that provides mechanisms and techniques to interconnect a wide range of digital devices to automate real-life systems. Gardeners facing problems in their gardens regarding the maintenance and availability of proper gardeners. This research paper has proposed an IoT-based approach for smart gardens using the NodeMCU microcontroller that helps the users in identifying current parameters of temperature, moisture, and humidity of their homegrown plants and gardens. The objective of this study is: 1) to design and develop the prototype product smart garden; 2) To integrate the smart garden with IoT technology; and 3) To validate the integration of smart garden with IoT technology by conducting the Unit Testing. Agile modal is implemented to ensure the product can be developed according to the specific period of time. A prototype has been implemented to show the real illustration of the proposed approach. A telegram bot application has been developed to display the real-time profiles of environmental factors like temperature, moisture, and humidity. With the help of this product, users will be able to treat their gardens in a better way in terms of plant growth, maximize the output while minimizing the cost of production.

Keywords: - Internet of Things (IoT), smart garden, telegram bot application

1 Introduction

With the continuous growth of technology, automation plays an important role to monitor, maintain and enhance the capacities, efficiencies, and production quality of every human activity (Yeo et al., 2014). With the existence of the Internet of Things (IoT), the automation field has become more accurate and precise. This is because people can monitor and maintain their products through their smart devices such as smartphones and computers.

According to Patel et al (Patel and Patel, 2016), IoT is a concept and a paradigm that considers pervasive presence in the environment of a variety of things/objects through a wired or wireless internet connection. The things/object consists unique address that is able to interact each other and also corporate with other things/object to create new application or services. (Galhena et al., 2013).

Since the implementation of IoT into automation gives a great advantage, however the need to implement automation technology in gardening is also crucial. This is because according to Galhena et al (Galhena et al., 2013) in 2050, global food production will need to increase by 70 % to meet the average daily caloric requirement of the world population.

However, most of the gardeners still implement the traditional method to run and maintain their garden. This will give a great problem to the gardener in terms of human factor and plant health. For example, the gardener is required to watering their plant manually twice every day. Other than that, gardeners need to turn on the light every night to ensure the plant can grow at minimum period of time. Besides that, in order to ensure plant healthy, gardeners are required to check and maintain the humidity and temperature of the plant. If the temperature or humidity is not conducive then the tendency the plant death is high. Last but not least, since traditional gardening is maintained manually, therefore a specific number of workers is required. This will cause a cost to hire a worker. Other than that, not all the workers have the experience and skills to maintain or monitor the garden. With inexperienced workers, it will affect plant growth and output production.

The remaining of this paper is organized as follows: Section 2 describes literature review that includes IoT and related study about gardening. Section 3 discusses the methodology; Section 4 presents the prototype of the smart garden; Section 5 discusses about product result and Section 6 concludes this study.

2. Literature Review

There have been a number of studies that attempt to define the IoT model of layers architecture. According to the previous study by Abdul-Qawy et al. 2015 mentioned that IoT can be divided into 5 layers which are the physical layer, the MAC layer, adaption layer, network layer, and adaption layer. Other than that, Patel et al (Patel and Patel, 2016) defined the IoT architecture with 4 layers which are smart device/sensor layer - The lowest layer is made up of smart objects integrated with sensors, network/communication layer - a massive volume of data will be produced by these tiny sensors and this requires a robust and high performance wired or wireless network infrastructure as a transport medium, application support layer - renders the processing of information possible through analytics, security controls, process modelling and management of devices and application layer - covers “smart” environments/spaces in domains such as : transportation and supply chain. As reviewed in the existing studies, we can broadly classify that IoT architecture consists of three layers that incorporate device layer – physical device and sensors, network layer – communication channel to transmit the data from device layer to the application layer, and application layer - services and analytical information to specific users.

Since the integration of gardening and IoT technology gives the advantage to the gardener, However, there has been some previous study still used the traditional gardening method for their garden. For example, Immaculate et al. (Mugisa et al., 2016) proposed a guideline to establish and manage home gardens. The authors do not implement the IoT technology to help users to increase garden productivity. The authors also mentioned that to maximise the garden output, soil fertilization and water supplementation should be maintained at all times. Therefore, to achieve that, the gardener needs to hire a worker to monitor their garden every day. Other than that, a previous study by Al-Bahadly and Thompson (2015) proposed a system that is capable of measuring the amount the moisture of the soil and determining whether or not the soil required water. The system used a Teensy 2.0 microcontroller to control the motorized valves and reading signals from the moisture sensing circuits. However, the system is incapable to alert the user if their plant moisture is low. The system is also unable to monitor the plant soil temperature since the optimum temperature is important to ensure the plant can grow healthy (Hatfield and Prueger, 2015).

Therefore, in this study, we attempt to design and develop a prototype product to demonstrate the integration of smart gardens with IoT technology with the aim to help gardeners to monitor and maintain their garden with their electronic devices with an internet connection.

3. Methodology

To complete this project, Agile methodology is implemented to ensure all requirement is fulfilled and validated. According to Sharma et al. 2012, the agile methodology consists of 7 phases follow the software development lifecycle which includes (1) Requirements: to collect requirements, some research has been conducted to identify problem arise in gardening. Based on the research result, it can be concluded that gardeners want to make their garden more efficient, smart and can maximise the output production while minimising the cost; (2) Design: to design the product, various software is used such as Microsoft Visio to sketch the flow of the process of the product; (3) Development: in this phase, the product is developed based on the design in phase 2; (4) Testing: After the product is design and developed successfully, the product will undergo testing/validation process to ensure all the product functionality is running as expected and no logic error occurs. A logic error is an error in a program that gives way to unanticipated and erroneous behaviour (Ettles et al., 2018); (5) Deployment: In this phase, the product will be implemented to the real environment to ensure all the functionality is functioning as expected; (6) Review: Solicit feedback from the user and gather information to incorporate into the next sprint.

4. Hardware and Software Requirement

4.1 Hardware

a. NodeMCU Esp8266

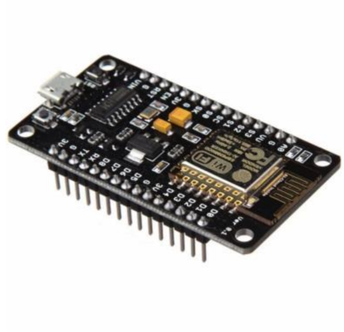

Figure 1: NodeMCU Esp8266

Based on Figure 1, NodeMCU is a digital microcontroller based upon system on chip (SoC) technology to develop IoT applications. It contains an onboard Wi-Fi system for the communication of data and other supporting libraries. MCU refers to the Micro Controller Unit. It provides the facility for analyzing, controlling, and monitoring digital systems. Here are a few prominent features of NodeMCU, Figure 4 shows NodeMCU as follows:

- Open Source
- System on Chip Technology
- Low Cost
- Easily Programmable
- Simple IO Handling

b. Arduino Uno R3

Figure 2: Arduino Uno R3

Based on Figure 2, Arduino Uno R3 is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs – light on a sensor, a finger on a button and turn it into an output – activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. Arduino programming language is based on Wiring and the Arduino Software (IDE).

c. Soil Moisture Sensor

The soil moisture sensor is most sensitive to ambient humidity is generally used to detect the moisture content of the soil. The digital output D0 can be connected directly with the microcontroller to detect high and low by the microcontroller to detect soil moisture. Figure 3 shows the soil moisture sensor.

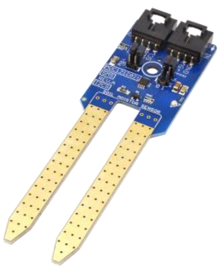

Figure 3: Soil moisture sensor

d. DHT11 Temperature and Humidity Sensor

Figure 4 shows the DHT11 Temperature and Humidity sensor is used. The total amount of water vapor in the air is defined as a measure of humidity. The relative humidity is calculated because when there is a change in temperature, relative humidity also changed. The temperature and humidity changes occur before and after irrigation. The amount of water droplets in the air is increased after irrigation. This causes a decrease in temperature which in turn increases the relative humidity of the surroundings. The temperature and humidity reading are often notified to the user so that the user can be able to know the field conditions from anywhere. The temperature and humidity sensor can also be used in greenhouses.

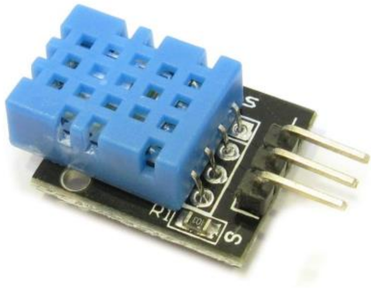

Figure 4: DHT11 temperature and humidity sensor

e. Solenoid Water Valve

Figure 5: Solenoid water valve

Control units which, when electrically energized or de-energized, either shut off or allow fluid flow. The actuator takes the form of an electromagnet. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring. Figure 5 shows the solenoid water valve.

4.2 *Software*

a. Arduino IDE

Arduino Software is an open-source Integrated Development Environment (IDE) that enables the user to write a code and to upload it into Arduino. It runs on multiple platforms which is Window, Linux and Mac OS X. Arduino supported HTML language to be coded inside Arduino. The importance of having this supportive functionality is because HTML is needed to code the web server as the interface to control and monitor the system. Figure 6 shows the Arduino IDE software interface.

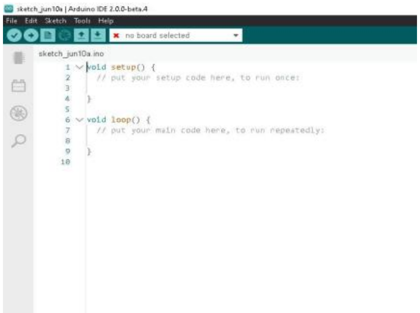

Figure 6: Arduino IDE

b. Telegram Bot

Telegram bot is the application that allows the user to insert specific command according to the requirement. Figure 7 shows the example of an existing telegram bot.

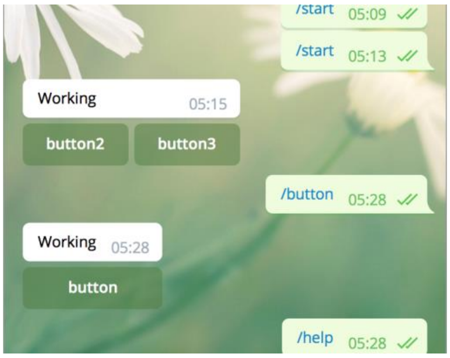

Figure 7: Telegram bot interface

5. Result and Discussion

Figure 8 shows the telegram bot interface that allows the user to interact with the product. Users are allowing to perform specific actions such as turn on/off led, check the humidity and moisture of plant soil. To perform a specific action, users are required to type-specific commands so that, the product can view output based on the command. The list of commands can be found in Table 1.

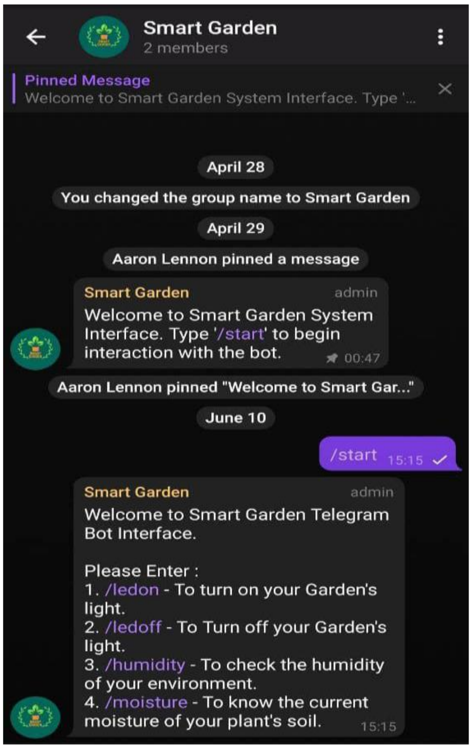

Figure 8: Smart garden Telegram bot interface

Table 1: The list of commands for smart garden Telegram bot.

Command	Function
`/ledon`	To turn on the light.
`/ledoff`	To turn off the light.
`/humidity`	To check humidity percentage, check temperature and heat index in both Celsius and Fahrenheit.
`/moisture`	To check moisture percentage of soil. If lower than 20%, water pump will automatically be watering the plant.

6. Conclusion

As a conclusion, the proposed product is designed and developed successfully. With the proposed product, it will give a great advantage to the gardener to maintain and monitor their garden without being there physically.

The product allows gardeners to perform a specific action such as check humidity and moisture plant-soil anywhere and anytime with the internet connection. Then, if the action is successful, then the success message will be displayed at the smart garden telegram bot. Other than that, the product is also able to minimize human error because the garden is monitored 24/7 by a specific sensor. Therefore, gardeners do not require to hire workers to monitor and maintain the garden. This approach able to maximize output production while minimizing the time and cost of production.

Acknowledgment

The authors express appreciation to the Politeknik Mukah Sarawak (PMU). The authors thanks to the anonymous reviewers for the feedback and PMU for supporting this research.

References

Abdul-Qawy, A. S., Pramod, P. J., Magesh, E., & Srinivasulu, T. (2015). The internet of things (iot): An overview. *International Journal of Engineering Research and Applications*, *1*(5), 71-82.

Galhena, D. H., Freed, R., & Maredia, K. M. (2013). Home gardens: a promising approach to enhance household food security and wellbeing. Agriculture and Food Security, *2*(1), 8. https://doi.org/10.1186/ 2048-7010-2-8.

Hatfield, J. L., & Prueger, J. H. (2015). Temperature extremes: Effect on plant growth and development. *Weather and climate extremes*, *10*, 4-10. https://doi.org/ 10.1016/j.wace.2015.08.001.

Mugisa, I., Molly, A., Gafabusa, R., Kituuba, G., Kyampeire, B., Atim, J., Nampeera, M., Nafula, R., Sseruwu, G., Kabanyoro, R., & Akello, B. (2016). A Farmers guide to home gardening: how to establish and manage home gardens. *NARO-Mukono Zonal Agricultural Research and Development Institute, Uganda.*

Patel, K. K., & Patel, S. M. (2016). Internet of things-IOT: definition, characteristics, architecture, enabling technologies, application & future challenges. *International journal of engineering science and computing*, *6*(5). https://doi.org/10.4010/2016.1482.

Sharma, S., Sarkar, D., & Gupta, D. (2012). Agile processes and methodologies: A conceptual study. *International journal on computer science and Engineering*, *4*(5), 892.

Yeo, K. S., Chian, M. C., & Ng, T. C. W. (2014, December). Internet of Things: Trends, challenges and applications. In *2014 International Symposium on Integrated Circuits (ISIC)* (pp. 568-571). IEEE. https://doi. org/10.1109/ISICIR.2014.7029523.

Al-Bahadly, I., & Thompson, J. (2015, December). Garden watering system based on moisture sensing. In *2015 9th International Conference on Sensing Technology (ICST)* (pp. 263-268). IEEE. https://doi.org/10.1109/ICSensT.2015.7438404.

Ettles, A., Luxton-Reilly, A., & Denny, P. (2018, January). Common logic errors made by novice programmers. In *Proceedings of the 20th Australasian Computing Education Conference* (pp. 83-89). https://doi.org/ 10.1145/3160489.3160493.